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Extraperiosteal Plombage with Polystan Sponge.  
Collapse Therapy in Severe Pylmonary Tuberculosis.

by

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Extrapariosteal pneumonolysis with the Polystan sponge was used by us for the first time on November 18, 1950. During the subsequent year, we performed this operation with the same technique 90 times on 80 patients, establishing 87 plombe spaces. In this paper we shall present the results of the first 52 consecutive cases operated upon at the Chest Hospital of Copenhagen and followed up for a minimum of one year.

#### PRINCIPLES OF THE METHOD

##### 1. Preservation of Ribs.

For a long time, efforts have been made to obtain permanent collapse of parts of the lungs affected with severe tuberculous lesions without sacrificing the bony thorax. Even the most selective form of thoracoplasty (of any extent) will entail permanent sequelae, viz. major or minor deformity, not infrequently persistent pain, and limited mobility of the shoulder and arm - despite adequate physical therapy instituted immediately after the operation. In the presence of emphysema or heart disease, major thoracoplasty entails persistent dyspnoea. During the post-operative period, thoracoplasty involves a risk of paradoxical respiration, atelectasis, and spread of the tuberculosis. This risk may be considerably reduced by carrying out the operation in sufficiently small - and consequently sufficiently many - stages. This, however, increases the psychic trauma.

Extrapleural pneumonolysis permits collapse of the lung while the bony thorax is left intact. It is not, however, applicable in severe tuberculous lesions requiring a permanent collapse. The procedures of fat implantation (Tuffier), paraffin plombage (Baer (a) ), etc. have been practically abandoned. Combined collapse operations, i.e. limited thoracoplasty with apicolysis and extrapleural pneumonolysis (Graf, Aycock,  
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et al., Gravesen, Rischel) have not gained much ground. Sufficient experience has not yet accumulated, although some late results have been reported by Buhl. The latest modification of the Holst operation is also of combined thoracoplasty and extrapleural pneumonolysis, but with covering of the lung against the pneumonolysis space, as a continuous and adherent fibro-musculo-osseous layer is sutured over the apex and to the inside of the chest wall as well as to the mediastinal pleura. Semb's modified method (b) differs from his original procedure (a), as small pieces of bone are placed on the periosteum over the covered apex. This makes for a more rapid regeneration of the ribs. G. Maurer's combined collapse operation - using the scapula as an intrathoracic "plombe" - spares the bony thorax to a certain extent. Pending further experience, however, we cannot assess the value of these methods.

The bony thorax is better preserved by the Paneth and Bailey methods which do not involve removal of any ribs. Especially with the last-mentioned method, the entire collapsed apex is covered with intercostal muscles and periosteum in a continuous layer, just as in ordinary thoracoplasty. The ribs are preserved (but denuded of periosteum). They receive their nutrition from the bone marrow (and from the wound effusion?). The thoracic stability is practically speaking equally well preserved by the Overholt costoverision thoracoplasty.

Preservation of the ribs reduces the operative risk; paradoxical respiration, atelectasis, and tuberculous spread are less apt to occur. Deformity of the chest and reduced mobility of the arm are avoided. Even total pneumonolysis may as a rule be accomplished in one stage, when the ribs are preserved.

## 2. Prevention of Local Complications.

The solid covering of the apex in ordinary thoracoplasty and in pneumonolysis of the Bailey and Overholt types almost entirely obviates the risk of local complications. We call these types of pneumonolysis extraperiosteal\*), because the periosteum (and, in continuation, the intercostal muscles with the intercostal vessels) is preserved as a solid covering layer over the tuberculous part of the lung. The superficial part of cavities, particularly large ones adherent to the chest wall, is not infrequently supplied by the intercostal arteries and is drained in part through intercostal veins and lymphatics. These important patho-physiological factors are respected in extraperiosteal, not in extrapleural pneumonolysis. Therefore, thoracoplasty is very seldom followed by cavity necrosis which is a common complication following intrapleural and extrapleural pneumonolysis in the presence of superficial cavities.

When a correctly performed extraperiosteal pneumonolysis is followed by space infection, the source is probably in most cases lymphatics and lymph nodes which are inevitably damaged in freeing the lung over the cupula and in the costovertebral gutter. Like other workers, we have in several instances been able to demonstrate tubercle bacilli and pyogenous cocci in the lymph nodes posteriorly in the upper intercostal spaces. Another, evidently more uncommon cause of tuberculous space infection (and of bronchial fistula) may be cavity wall necrosis due to ligation of the upper intercostal vessels in apicolysis which compromises the blood supply to the superficial cavity wall. As a rule, however, the supply of arterial blood through anterior and inferior anastomoses proves sufficient.

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\*) The "extraperiosteal" thoracoplasty and apicolysis procedures previously used by A. Maurer and W. Kremer (a) are entirely different methods, worked out on principles and points of view differing widely from ours.

With extensive apicolysis in the presence of large cavities, however, the patho-physiological condition following extraperiosteal pneumonolysis may partly resemble that which is risked in extrapleural pneumonolysis: A too limited blood supply and a consequent risk of cavity necrosis.

In this way, there will be a competition between the advantages of extensive apicolysis and the risk of cavity necrosis resulting in tuberculous space infection and bronchial fistula.

It is generally recognized that extraperiosteal pneumonolysis is less apt to be followed by local complications than the extrapleural method. Extrapleural pneumothorax resulted in tuberculous empyema in 16% of J.H.E. Roberts' patients. Bronchia fistulae occurred in 10% of the Rohrbach series (Heidelberg). Extrapleural paraffin plombes have been almost entirely abandoned. Plombage with polymethyl metacrylate (lucite balls) was followed by extrapleural tuberculous empyemas in 21.5% (Trent et al.). Following extrapleural plombage with Polystan sponge and Spongostan (gel foam) Linden & v. Rosen have reported bronchial fistula with tuberculous infection in 10%.

These complications are far less common following extraperiosteal pneumonolysis, i.e. ordinary thoracoplasty (with sub-periosteal rib resections) or the Bailey and Overholt types. Kremer (b) is now reported to employ extraperiosteal paraffin plombage. Lucas & Cleland use lucite balls or solid polyethylene ("Polythene") spheres, Morrison Davies et al. extraperiosteal polythene packs. In these English series, bronchial fistulae and tuberculous infection occurred in only about 1%. v. Rosen has also adopted extraperiosteal plombage.

### 3. Ensuring Permanent Collapse. - Types of Plombes.

Insufflation of air, filling with oil, paraffin plombes, or tissue transplantation have proved unsatisfactory means of preserving a permanent collapse.

which appears to ensure collapse, but no late results have yet been published. The advent of plastics afforded plombage material which is chemically indifferent and which may be made in practically any desirable physical property. Although Kleinschmidt, as early as 1941, had introduced plastics in surgery, major experiments with these substances in collapse therapy of pulmonary tuberculosis were not instituted until after the war. Wilson introduced lucite balls in 1946, Morrison Davies polythene packs in 1948, and Bing the Polystan sponge in 1950. Today there is hardly any doubt that the spongy plombe has marked advantages above other types with a smooth, continuous surface. We have abandoned the original plombe, which is too soft, and now use a somewhat harder Polystan sponge the shape of which fits a normal apicolysis space. Fixation in the tissues, through ingrowth of connective tissue in the meshes of the Polystan sponge, is a sine qua non, if a large foreign body is to be tolerated, particularly by an organism with chronic inflammation in the vicinity.

Plombes with a smooth surface have frequently given rise to effusion, infection, and other complications. Lucas & Cleland reported effusion in 18 out of 125 cases and rupture of the wound in five following extraperiosteal plombage with lucite balls and polythene spheres. In 17 out of 102 cases, Morrison Davies et al. had to remove the extraperiosteal polythene pack because of effusion or infection. In our opinion, the explanation is that smooth plombes rub against the walls of the pneumonolysis cavity in each respiration, i.e. more than 20,000 times in the 24 hours. According to biological experience, such constant traumatization of the tissue given rise to effusion. (This takes place irrespective of the chemically indifferent character of the plombe. It is a reaction to a purely physical trauma). The presence of effusion increases the risk of infection. The movements of the plombe in relation to the tissues will be the more marked, the bigger the plombe. The smaller, multiple plombes in Lucas & Cleland's series gradually become fixed to a certain extent. Unlike Morrison Davies'

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larger solitary pack, they have more rarely given rise to infection, and their removal has been required only in exceptional cases.

The considerable incidence of complications which followed upon Linden and v. Rosen's application of the Polystan sponge was due to the extrapleural insertion of the plombe. In addition, the combination with Spongostan in their series gave rise to marked effusion during the first post-operative weeks.

According to what has been stated above, we feel that when plombage is indicated, extraperiosteal plombage with a chemically indifferent substance which may be fixed by the tissues is the most attractive method, in theory as well as in practice. Of the plastic plombs made to date, the Polystan sponge appears to be most suitable in the permanent collapse therapy of pulmonary tuberculosis.

It must be pointed out that the plombe is only expected to ensure collapse until ribs have regenerated at the end of three months. From that time on, the regenerated ribs provide permanent collapse and immobilization.

#### INDICATIONS

Unlike most previous authors on the use of plastics in the surgical collapse therapy of pulmonary tuberculosis, we have used this method only in strictly selected cases - i.e. those which are inoperable or poor surgical risks according to ordinary criteria. These indications correspond approximately to Baer's (b) "relative indications" for paraffin plombage 30 years ago. Only 18% of 263 patients in 1951 had extraperiosteal Polystan plombage, while 52% had other surgical collapse procedures, and 30% were treated by pulmonary resection.

Extrapariosteal plombage was used primarily in cases believed to be unsuitable for any other operation. (1) Pronounced pulmonary emphysema, bronchitis, bronchial asthma, severe cor pulmonale, pronounced obesity, advanced age, etc., are indications for the procedure. (2) Another group of indications includes severe contralateral lesions or contralateral pneumothorax, previous or planned con-



tralateral operation. Often these indications are combined. (3) In the presence of superficial, rather large sub-apical or lower cavities, which so far have been deemed suitable for extrapleural pneumonolysis because a thoracoplasty would have to be too extensive, we used extraperiosteal plom-bage in an endeavour to reduce the incidence of cavity rupture and empyema.

It is not our intention to let extraperiosteal plombage replace any of the old-established surgical procedures in cases where the latter may be safely used. Plombage was preferably used as a supplement to those operations which have been available so far in the treatment of pulmonary tuberculosis. For the time being, plombage is, in our opinion, primarily a procedure to be used when traditional methods are considered too risky.

#### OPERATIVE TECHNIQUE.

The extent of the operation is determined as in thoracoplasty. It is carried out like thoracoplasty, stripping the periosteum from the ribs. The only difference is the preservation of the ribs. As a rule apicolysis (by the Semb method (a) ) is performed. In a cautious and gentle operation, a continuous, well vascularized layer of intercostal muscles and periosteum is preserved over the collapsed part of the lung. On top of this, the Polystan sponge is placed. It is fixed by the denuded ribs. The plombe is separated from the critical area of the collapsed upper lobe by osteogenic tissue. The details of the technique have been described elsewhere (Hansen & Engberg). More detailed descriptions of the operative procedures have been published by Maraschio (in whose series, however, the Polystan sponge was supplemented with Spongostan) and By Morrison Davies et al. whose procedure is in all essentials like ours, only performed with another type of plombe.

#### AFTER-TREATMENT.

Following extraperiosteal prombage, antibiotics are administered for five or six days as a prophylaxis against pyogenic infection. Antibiotic therapy



directed against the tuberculosis, if indicated, is administered before the operation and continued on the usual lines. On the second post-operative day, effusion and blood are aspirated from the space. The paracentesis is repeated once or twice during the first ten post-operative days, if indicated by the X-ray appearances and pressure symptoms, if any. Air may be injected into the plombe from the 10th to the 14th day, if a particularly intensive collapse is desired, viz. in medial or very large cavities. The plombe capsule can resist pressures of 120 to 140 cm of water at the end of a few weeks. The insufflations are continued, if required, during the two or three months following the plombage - at increasing intervals. Further refills are unnecessary and ineffective, as ribs have regenerated over the collapsed area.

Should a residual cavity persist at the end of three months, its size and character must decide further treatment. Small remnants of a cavity often have a tendency to close by shrinkage owing to the immobilization under the regenerated ribs, as is seen following thoracoplasty. Larger residual cavities which fail to exhibit a tendency to shrink on conservative therapy, should be treated by pulmonary resection below the plombe capsule through a standard thoracotomy below the area of the capsule. In cases of collapse failure following subtotal or total extraperiosteal plombage, the lung resection (pneumonectomy) is performed through an anterior vertical thoracotomy. Pulmonary resection below a plombage is carried out in exactly the same manner as following thoracoplasty, but it involves an extra risk owing to the possibility of a plombe space infection, if rupture of an adherent cavity should occur during the intervention. In our experience, secondary resection of the lung (as well as cavity drainage) should not be done until three or four months, preferably not until six months after the plombage. At that time, the oedema has been replaced by fibrosis, and the plombe capsule as well as the regenerated ribs form a solid barrier between the operative field and the plombe.

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POSTOPERATIVE COMPLICATIONS.

The 90 extraperiosteal plombage operations with Polystan sponge on 86 patients were not followed by serious complications, deaths, or spread of the tuberculous infection. As a matter of routine, serosanguinolent effusion was aspirated once or twice, but this cannot be counted as a complication. The effusion is due to hemorrhage, as the hemoglobin content in the aspirated fluid is usually about 50 - 60%. Infection was not demonstrated in any case despite routine cultures (anaerobic and aerobic) from all the fluids for tubercle bacilli and pyogenic bacteria.

TABLE I

The complications are presented in Table 1. Tear of the pleura occurred in four instances without essentially influencing the respiration or the general condition. Following treatment (needle aspiration in three cases, under-water drainage for two days in one) total re-expansion of the lung below the area of the plombe was obtained. Atelectasis, due to intrabronchial stagnation of secretion in two instances and to the pressure of the effusion in a third case, immediately yielded to treatment (aspiration of the effusion and bronchoscopy). Two patients developed effusion, necessitating four aspirations in the course of the first two post-operative weeks, yielding a total of 1700 and 800 ml respectively. Then, the effusion ceased, and no infection occurred. Each time, the aspirated fluid showed a hemoglobin content of 60 - 65%, so that in these cases also the effusion appears to have been due to hemorrhage. Total rupture of the wound occurred on the tenth post-operative day in one of our earliest cases (a 61-year old man with severe chronic bilateral lesions, case record 4/51). Contrary to our custom, aspiration had not been performed, and the rupture was presumably due to the effusion. Following re-suture, the course was uneventful. Although the plombe space had been open to non-sterile surroundings, no infection occurred until the patient

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suddenly died in his home from hemoptysis (from a contralateral, non-operated cavity).

These 90 operations were, thus, followed by complications - exclusively mild ones - in a total of eight cases (9%) during the first few post-operative weeks. None of these complications differed from those seen following thoracoplasty in ordinary series. Their incidence would doubtless have been perceptibly higher following thoracoplasty in a material of such poor risks as the present one. The preservation of the denuded ribs did not give rise to complications.

#### GENTLENESS OF THE OPERATION

Extraperiosteal pneumonolysis with Polystan sponge plombage has completely fulfilled the expectations that it is a very gentle collapse operation. The complications have not influenced the patients' health. The fact that no deaths have attended 90 operations on 80 patients, most of whom were in poor general condition, demonstrates the slight influence of the intervention on the cardiac and pulmonary function. The absence of post-operative spread and re-activation of existent foci in this series, which consisted chiefly of severe cases, illustrates the gentleness to the diseased lungs. The earliest juncture at which spread occurred was three months after the plombage in a streptomycin-resistant patient who succumbed at the end of 10 months (90/51). Another fact which illustrates the slight influence of this intervention on the respiratory function is that in three instances bilateral plombage could be carried out in one stage.

One of these patients was a 51-year old male (959/51) with mild heart disease (bundle branch block). On both sides the plombes reached the 7th rib (Fig. 3). The patient developed a tear in the left pleura with resulting pneumothorax and a small intrapleural effusion. Another male patient, 33 years of age, (377/51), had bilateral plombage in one stage to the sixth and fifth ribs respectively. A female, aged 28, (307/51), had bilateral pneumonolysis in one

stage, to the sixth rib on both sides. None of them exhibited post-operative dyspnoea worth mentioning. One was able to sit up in bed two hours after the operation during a demonstration for surgeons who were visiting the hospital. In one case (female, aged 26, 696/51) bilateral plombage was carried out in two stages with an interval of only 19 days without untoward effects. In the case of a 32-year old male (641/51) preoperative bronchspirometry had shown that the left lung contributed only 10% of the total pulmonary function, ventilation, diffusion, and reserve, as it had previously been affected with severe lesions. And yet, he exhibited only moderate dyspnoea following right-sided extraperiosteal Polystan sponge plombage. This patient could not tolerate streptomycin or PAS and did not receive either. He developed a staphylococcal space infection, requiring, two months later, a re-operation with removal of the plombe and a seven-rib thoracoplasty. This intervention also was not followed by respiratory disturbances. A 24-years old male (358/51) had a history of right-sided tuberculous empyema. Decortication of the pleura, which was 2 - 3 cm thick, injured a small, hitherto unrecognized cavity, and the operation only made the pulmonary function poorer, as a new empyema developed. In the course of extraperiosteal plombage to the 6th rib on the left, three months after the right-sided decortication, the pleura was torn. This did not, however, lead to major dyspnoea. One year after surgery, all these six patients are without clinical signs of disease and without demonstrable cavities. The last-mentioned patient is sputum positive (but only one colony on culture), whereas the others are sputum negative.

#### FOLLOW-UP SERIES

The first 52 consecutive patients who had extraperiosteal Polystan sponge plombage at the Øresund Hospital have been followed up for one year. Seven have had bilateral plombage (three in one and four in two stages). In one case, an extensive unilateral plombage was carried out in two stages. In other words,

these 52 patients had a total of 60 operations, and 59 plombage spaces were established. If thoracoplasty had been performed to obtain a similar extent of collapse as that planned in the extraperiosteal plombage in this series, we have calculated (on the basis of our ordinary clinical and radiological criteria) that 152 operations would have been required. These 52 patients have, therefore, been saved 92 operations - and a high operative risk.

THE SEX RATIO AND AGE DISTRIBUTION WILL BE SEEN FROM TABLE 2

TABLE 2

There is a relatively large proportion of elderly patients, as 38% were over 40 years of age. In two previous series of thoracoplasty from this hospital only 11% and 20% respectively were over 40 (Hagn-Meincke; Kjaer & Hansen).

The severity of the tuberculous lesions was evaluated on the basis of Cold's classification. In this series, only 20% could be assigned to Group I (exclusively unilateral or mild bilateral lesions without contralateral activity), while 42% belong to Groups III and IV (severe bilateral lesions or bilateral cavities). In Hagn-Meincke's series 53% belonged to Group I and only 8% to Groups III and IV. In Kjaer & Hansen's series the corresponding values were 54% and 9%. These two series include all thoracoplasties (664 cases) performed in the hospital from 1935 to 1945 inclusive.

Table 3 gives the causes why extraperiosteal plombage was preferred to other procedures.

TABLE 3

OPERATIVE CRITERIA.

The 10 patients deemed too poor risks for any other operations were as follows:

Two with severe dyspnoea, two with a history of contralateral pleurisy as well

as bronchial asthma and emphysema, two with extensive contralateral extrapleural pneumothorax, two considerably obese subjects about 60 years of age, one patient with a history of contralateral empyema and with severe dyspnoea. In the last-mentioned case pulmonary resection was planned, but the patient took ill when the anaesthesia was started and therefore had plombage instead.

The 31 patients with contralateral lesions: Sixteen with ~~contralateral~~ cavities (five of them had bilateral plombage), eight had contralateral artificial pneumothorax, two had contralateral extrapleural pneumothorax, one had had contralateral thoracoplasty and exhibited less marked, presumably inactive changes on the contralateral side. Three patients with slight apical lesions had plombage, because they asked for the smallest possible intervention and were reluctant to undergo thoracoplasty. In six cases of superficial cavities, plombage was preferred, in three partly because of age (over 45) and in the other three partly because of extremely superficial cavities making extrapleural pneumothorax too risky, and partly because it was believed that thoracoplasty would have become too extensive. In two instances it was considered inadvisable to choose a procedure which pre-supposed after-treatment with pneumothorax - as one lived far from any phthisiologist and the other one was asocial. In the latter case, a thoracoplasty in several stages was also out of the question.

In five cases, bacillary resistance to streptomycin and PAS had been ascertained prior to the operation. In another two cases antibiotic therapy had been discontinued after a short time because of intolerance, before the operation was decided. Isonicotinic acid hydrazide was not available at the time when this series was treated.

Out of the 52 patients, 11 remained for after-treatment in the hospital, while 41 received their after-treatment in eleven different sanatoria in Denmark.

LATE COMPLICATIONS

Table 4 presents the late complications in the follow-up series.

TABLE 4

Staphylococcic space infection occurred in three cases (case records 641/51, 208/51, 612/51) two, eight, and fourteen months respectively after the plom-bage. The symptoms were slight oppression and moderately or higher elevated temperature and erythrocyte sedimentation rate. The general health remained relatively unaffected. Following preliminary antibiotic therapy, according to sensitivity tests of the bacteria from the aspirated fluid, re-operations were performed with removal of the plombe and the over-lying ribs, and, if re-quired, also the lower part of the scapula. The re-operations did not affect the pulmonary function, as the firm plombe capsule and the regenerated ribs rendered the intervention physiologically a purely extrathoracic one. The wounds healed normally with drainage. All three patients were cured of their tuberculosis after the plombage, and their sputa have remained negative through-out the follow-up period. No tubercle bacilli were found in the space, and there were no bronchial fistulae. In these instances, there has probably been a question of lymphogenous or haematogenous infection.

One patient (840/51), while in a sanatorium, received repeated oil injections into the plombe to prevent its shrinkage. Two months after the operation, he developed a staphylococcic space infection. Since in this case the infection developed after an injection of oil (the fourth injection) it was probably due to bacteria introduced with the injection. (We have seen two other cases devel-oping infections after oil injections into the space, but these cases had the primary operations in a sanatorium, and are, therefore, not included in the pres-ent series from the hospital.)

In two instances, pulmonary resection because of residual cavity (90/51, 536/51) was followed by tuberculous space infection with bronchial fistulae.



In one of these cases, the pulmonary resection was performed two months after the plombage, and this has no doubt been too early. In the other case, the interval was four months. In both these instances, the cavity was firmly adherent to the under surface of the plombe capsule, so that rupture of the cavity and injury of the plombe capsule occurred in the course of resection. Both had thoracoplasty and removal of the plombe. One of these patients (90/51) died six months later from slowly progressing bilateral lesions, whereas the other one (536/51) is sputum negative and has only a small fistula. However, resection of the clavicle was needed to close the space.

In one case (4/51) the plombe and the overlying ribs were removed seven months after the operation because of constant complaints of pain. It is doubtful, however, whether real pain was present. Another patient has also complained of pain, but has not received any special treatment. The presence of late pain in two out of 52 cases (4%) following extraperiosteal Polystan sponge plombage does not distinguish this operation from ordinary thoracoplasty. In a material treated by the latter procedure and studied particularly with a view to late intercostal neuralgia, chronic pain was noted in 3 out of 50 cases (6%) Hensen.

Late complications, accordingly, occurred in a total of eight of the 52 cases with 60 plombage operations followed up for a minimum of one year (15% of the patients, 13% of the plombes). Three instances of space infection (5% of the 59 plombe spaces) are typical plombage complications which must be attributed to the method per se. The remaining three cases of space infection are artificial and should be avoidable in future series of plombage. It is doubtful whether the plombage as such is to be blamed for the late pain in two cases, as the incidence of this symptom is the same following thoracoplasty.

#### EFFECT OF THE PLOMBAGE ON THE TUBERCULOSIS

Table 5 gives the results of extraperiosteal Polystan sponge plombage at least one year after the operation.

TABLE 5

A total of 34 patients are sputum negative (65%), while 14 are still sputum positive (27%) and 4 have died during the follow-up period.

This result cannot, however, be attributed solely to the plombage operation, but also to secondary surgery. Pulmonary resection below the plombe area was done in five cases (4/51, 90/51, 798/51, 922/51, 536/51) because of persistent cavities. Lobectomy was carried out in three cases, pneumonectomy in one, and segmental resection in one. In three cases large residual cavities were present. Resection specimens revealed them in two cases to be extremely thick-walled and unsuitable for collapse therapy. In two cases of lung resection, the remnants of cavities were so small that it is doubtful whether resection was justified, as they would probably in time have closed spontaneously due to the immobilization. The reason why pulmonary resection was carried out because of persistent positive findings in the sputum in these two cases (two and four months after the plombage) was lacking experience of the efficacy of the method. Four of the patients who had secondary pulmonary resection were rendered well and sputum negative, while a streptomycin-resistant patient (90/51) died from slow bilateral progression six months after the lobectomy. Secondary cavity drainage was carried out in two cases. One of the patients (591/51) who had had bilateral plombage in two stages, exhibited a residual cavity which closed after the drainage. She is now sputum negative. In the other case (297/51) the cavity was probably not a residual one, but a new cavity of a lower situation which persists despite the drainage.

In three of the 34 cases which have been cured to date, sputum conversion was not obtained until more than one year after surgery. Such late sputum conversion is not infrequent following ordinary thoracoplasty. Since only a small proportion of the series has been followed up for more than one year, sputum conversion may still occur in some of the positive cases.

Of the 14 patients with positive sputa three exhibit only one or at most a few colonies on cultures from repeated gastric washings.

The four deaths during the follow-up period (2/51, 4/51, 90/51, 574/51) occurred 14, 10, 10 and 6 months respectively after the extraperiosteal plombage. The causes of death were as follows: (1) Cor pulmonale and emphysema as well as a persisting contralateral tuberculous empyema which closed only in part following thoracoplasty; (2) haemoptysis from a contralateral, non-operated cavity (autopsy not performed); (3) slow bilateral progression in a streptomycin-resistant patient who, a couple of months after secondary lobectomy, developed a psychosis and refused to take food; (4) a similar progression and cor pulmonale in a patient who had had bilateral plombage in two stages 6 and 8 months respectively before death. At the time of the operation, this patient had an apical tuberculous empyema with a bronchial fistula, but no plombe space infection occurred.

The persistent findings of bacilli in the sputum following plombage may, in at least ten cases, be attributed to contralateral unoperated lesions existent before the operation.

In series of ordinary thoracoplasty, Hagn-Meincke and Refsum have reported 18% and 11% deaths respectively at the end of one year. To this may be added the post-operative deaths: 9% and 7% respectively, or a total of 27% and 18% respectively. These values are far in excess of our 8%. In the two thoracoplasty series, 50% and 37% respectively were sputum positive one year after thoracoplasty, as against 32% in the present series.

Table 6 sets out the good and the poor results (sputum conversion or not) in the two thoracoplasty series (in per cent of the original number of patients) at the end of one year's follow-up compared with the one-year results in the present plombage material (the three instances of sputum conversion after the

- 18 -

one-year limit are grouped with the poor results in this table).

TABLE 6

The table shows 60% good results one year after the plombage of preponderantly severe cases as against 29% and 48% respectively following thoracoplasty in mixed series with a preponderance of mild cases. Accordingly, the results of plombage to date easily stand comparison with the outcome of thoracoplasty in previous series, despite the marked difference in severity. Of course, anti-biotic therapy has afforded a great help in the cases treated by plombage; antibiotic agents were not available when the patients with thoracoplasty were treated. It is unlikely, however, that antibiotic therapy can have exerted essential influence on the sputum findings one year after surgery, if it has not entailed cavity closure.

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SUMMARY

The authors stress that preservation of the ribs in the surgical collapse therapy of pulmonary tuberculosis contributes essentially to preventing post-operative and late complications and that pneumonolysis according to the thoracoplasty principle is the safest procedure to obtain permanent collapse. Both principles are observed in extraperiosteal pneumonolysis. The collapse is maintained by plomage of the space between the lung and the ribs. The most suitable plomage material is the Polystan sponge, as ingrowth of connective tissue into the plombe ensures its fixation and thus counteracts complications.

This operation has been carried out in 80 cases of severe pulmonary tuberculosis (90 stages). It was reserved mainly for the poorest risks, unsuitable for the traditional collapse operations. The procedure was employed in only 18% of the cases operated on in 1951. Only 20% of the patients belonged to the mild Group I, 42% to the severe Groups III and IV. No post-operative deaths or serious complications occurred (Table 1.) Follow-up of 52 patients from 12 to 18 months after the operation revealed three spontaneous pyogenic space infections and three artificial space infections (Table 4.) Four patients had died during the follow-up period, 34 patients (65%) were cured at the time of the follow-up with sputum conversion and cavity closure, while 14 were still sputum positive (Table 5.) In at least 10 of the latter cases, the persistent sputum findings are explicable by contralateral, non-operated lesions.

\* \* \* \* \*

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Fig. 1. Extraperiosteal plombage in case of traditional thoracoplasty.

Fig. 1. A. Female, aged 42, case rec. No. 11/1951. Tomogram of cavity on a level with the 2nd - 5th ribs on the right.

Fig. 1. B. Same case as Fig. 1A. One year following extraperiosteal pneumonolysis with apicolysis and Polystan sponge plombage. Sputum negative. Cavity closed. Note the regenerated ribs between the apex and the plombe.

Fig. 2. Extraperiosteal plombage for giant cavity.

Fig. 2 A. Female, aged 55, case rec. No. 712/1951. Cavity of a diameter of 8 cm in the left upper lobe. Infiltration in upper and lower parts of the right lung. Severe dyspnoea.

Fig. 2 B. Same case as Fig. 2A. Following extraperiosteal pneumonolysis without apicolysis, plus Polystan sponge plombage. Insufflations of air into the plombe space. The infiltrations in the right lung have diminished. One year later no demonstrable cavity. Two colonies of tubercle bacilli in the gastric washing.

Fig. 3. Bilateral plombage in one stage.

Fig. 3 A. Male, aged 54, case rec. No. 959/1951. Multiple cavities in the upper lobes of both lungs.

Fig. 3 B. Same case as Fig. 3A. following bilateral extraperiosteal pneumonolysis with apicolysis and Polystan sponge plombage in one stage. One year later no demonstrable cavities. Sputum negative.

Fig. 4. Shrinkage of the plombe space due to a too soft plombe.

Fig. 4 A. Male, aged 28, case rec. No. 819/1951. One week after extraperiosteal pneumonolysis with apicolysis and plombage with the original Polystan sponge (S plombe). Good collapse.

Fig. 4 B. Same case as Fig. 4A. Four months after the operation, plombe space shrinkage. Poor collapse. Cavity reopened.

Fig. 5. Persistent cavity despite good collapse.

Fig. 5A. Male, aged 25, case rec. No. 536/1951. Giant cavity (diameter 6 cm) in the left apex.

Fig. 5 B. Same case as Fig. 5A. Two months after extraperiosteal pneumonolysis plus apicolysis with Ploystan sponge plombage. Cavity persists despite good collapse of the upper half of the lung.

Fig. 6. Subtotal extraperiosteal plombage.

Male, ages 22, case rec. No. 844/1952. One year after extraperiosteal Polystan sponge plombage down to the 10th rib for a destroyed left lung. (Infiltrations were also present on the right). Good collapse. Cavity closure. Sputum conversion. Note solid regeneration of ribs over the collapsed lung and partial absorption of the ribs superficial to the plombe.

\* \* \* \* \*

- a -

Table 1

Analysis of operative and postoperative complications of  
90 extraperiosteal Polystan plombage operations.

(80 patients, 87 plombe spaces).

Tear in pleura . . . . .	4	
Atelectasis . . . . .	3	
Rupture of wound . . . . .	1	
Complications, total . . . . .	8	( 9%)
No complications . . . . .	82	(91%)

Table 2

Follow-up series: Sex ratio and age distribution.

Age	Males	Females	Both sexes
20 - 29	11	6	17 (33%)
30 - 39	7	8	15 (29%)
40 - 49	7	5	12 (23%)
50 - 59	5	1	6) 2) (15%)
60 - 69	2		
Total	32	20	52

- b -

Table 3

Follow-up series:	
Criteria of extraperiosteal plombage.	
Too ill for other procedures . . . . .	10
Contralateral lesions . . . . .	31
Plombage preferred to extrapleural pneumothorax because of superficial cavity (thoracoplasty would have been too extensive to be tolerated). . . . .	6
Small apical cavity . . . . .	3
Easier after-treatment . . . . .	2
Total	52

Table 4

Follow-up series:	
Analysis of late complications in 52 cases (60 operations, 59 plombe spaces).	
Staphylococcic space infections (haematogenous, lymphogenous) . . . . .	3
Staphylococcic space infections (due to injection of oil) . . . . .	1
Tuberculous space infection (due to operative rupture of cavity and plombe capsule) . . . . .	2
Persistent pain (?) . . . . .	2
Late complications, total	8 (15%)
No complications	44 (85%)

- c -

Table 5

Sputum findings 12 - 18 months following extraperiosteal  
Polystan sponge plombage.

		Sputum negative	Sputum positive	Dead	Total
Bilateral plombage.	{Mild cases of bilateral cavities operated in one stage.	3	0	0	3
	{Severe cases - operated in two stages.	1	2	1	4
Unilateral plombage.	{Moderate contralateral lesions.	20	5	0	25
	{Severe contralateral lesions.	10	7	3	20
Total		34	14	4	52

Table 6

Results of one year's follow-up:

Thoracoplasty series and plombage series.

Author	Number of cases	Severe cases Groups III-IV  %	Mild cases Group I  %	Good results: sputum con- version cavity closure.  %	Poor results: Dead or sputum positive.  %
Hagn-Meincke	420	8	53	29	71
Refsum	391			48	52
Plombage	52	42	20	60	40